UDC 666.3

RAW MATERIALS AND WAYS TO INCREASE BUILDING CERAMICS PRODUCTION EFFICIENCY

N. F. Solodkii[1] and A. S. Shamrikov[1]

Translated from *Steklo i Keramika*, No. 1, pp. 26 – 29, January, 2009.

It is shown how the production efficiency of building ceramics — sanitary ware, facing tiles, and others — can be increased. Effective use of the mineral – raw material base of the Urals is one way to increase the production of building ceramics.

A very important socioeconomic problem in present-day Russia is to provide high-quality, affordable housing to the public. The government has made the solution of this problem a priority for the near-term future. However, it is virtually impossible to solve this problem without substantially increasing the production of building materials, expanding the assortment of energy-efficient ceramic materials, and reducing the materials and construction costs for housing.

Natural and artificial raw materials, divided into plastic (tiles and kaolins), grog (quartz sand, chamotte in the form of rejected articles and calcined plastic materials), and fluxes (feldspar, pegmatite, perlite, nepheline concentrates, syenites, trachytes, granites, felsites, slags, and others), are used to produce articles made of building ceramics.

The Urals are rich in practically all types of natural mineral – raw materials resources for the ceramic industry. Large reserves of refractory and low-melting clays, high-quality kaolins, and other types of nonmetalliferous raw materials are concentrated in the Chelyabinsk region.

Refractory clays (Nizhne-Uvel'skoe and Berlinskoe deposits) are one of the leading sites among other deposits in the Russian Federation with respect to reserves as well as quality. In the Chelyabinsk region 29,6% of all clay reserves in Russia are located in two worked deposits, and the production volume is 44.1% of the country's entire production. Clays are used in the production of refractories, sewage pipes, floor tiles, acid-resistant articles, as well as in mixes used for fabrication of sanitary ware and ceramic construction articles, facing tiles with opaque glazes, and in the production of electrotechnical porcelain, majolica, and ceramic granite.

"Keramicheskoe Byuro" JSC is conducting process supplementation with selective extraction of lower-Jurassic clay for the production of ceramic granite.

The region contains a number of deposits of white refractory clays (Smolinskoe, Sineglazovskoe, Kruglovskoe, "Uprun") which have been removed from the reserve inventory because of depletion and very low reserves. But because the quality of the clays is satisfactory for the production of fine ceramics it is desirable to re-evaluate these deposits and, if the results are positive, to put them into production.

The following deposits could be of definite interest for further investigation of raw materials in Chelyabinsk oblast':

clays from the Gorodishchenskoe deposit are similar, on the basis of the character and conditions of bedding, to the Berlinskoe and Buskul'skoe clays; the Al_2O_3 and Fe_2O_3 contents are, respectively, 21.5 – 33.5% and 0.2 – 0.5%;[2] the high plasticity and low content of coloring oxides suggest that these clays can be used as a plastic additive in porcelain and building ceramic mixes;

refractory clays from the Astaf'evskoe deposit, based on their mineral composition, are kaolinite – hydromicas; the $Al_2O_3 + TiO_2$ and Fe_2O_3 contents are, respectively, 15 – 40% and 0.6 – 2.4%;

the Kremenkul'skoe and Alabuzhskoe deposits have not been explored and studied; the area of the latter deposit is 50 ha and the bedding depth is 2 – 4 m; the clays are oily, shaly; the Al_2O_3 and Fe_2O_3 contents are, respectively, 21.5 – 34% and 1.8%.

clays from the Bredinskoe, Plovinskoe, and Uvel'skoe deposits are of definite interest as low-melting clays for the near-term future; these clays are suitable for the production of M-125 and M-150 construction-grade brick.

Glauconite-bearing rock is widely disseminated in the eastern part of Chelyabinsk oblast'. The predicted reserves are 297.3×10^6 tons.

Investigations performed over the last ten years have confirmed that glauconite-bearing raw materials are useful

[1] "Keramicheskoe Byuro" JSC, Yuzhnoural'sk, Russia.

[2] Here and below — content by weight.

0361-7610/09/0102-0026

for obtaining colored glasses, glazes, and crystalline glass materials as well as for applications as additives in the production of brick, unglazed tile, ceramic tiles, stony castings, fill for polyvinyl chloride compositions, and other materials.

Today, the Ural region is the only regional supplier of enriched kaolin in the Russian Federation. Only five of the explored deposits of eluvial kaolins in Russia are being worked: Nev'yanskoe (Sverlovsk oblast'), Kyshtymskoe, Eleninskoe, "Zhuravlinyi Log," and Poletaevskoe (Chelyabinsk oblast'). The Chekmakulskoe deposit is classified in the government inventory as a reserve deposit (Chelyabinsk oblast').

The prospects for increasing the resource base of kaolins in Chelyabinsk oblast' are unlimited. Category R_1 resources amount to 30 million tons in the Kyshtymskoe kaolin region, 46.6 million tons in the Chelyabinsk region, 60 million tons in the Kochkarskoe region, and 45 million tons in the Dzhabykskoe region. In addition, the predicted category R_3 resources over 10 promising sites coordinated mainly with the region of development of the main Urals granite belt amount to 354 million tons.

Substantial predicted resources of eluvial kaolins (about 0.5 billion tons) lie in the eastern part of Orenburg oblast' (Orskoe Zaural'e). In this connection, the development and improvement of the mineral – raw materials base of kaolins in the Urals is extremely important for the Federal government. Consequently, a target program for the development of the mineral – raw materials base of kaolins in 2000 – 2010 includes geological – survey work on the territory of the Urals for additional search for, discovery of, and exploration of category $R_1 + R_2$ kaolin reserves. However, it should be noted that there are no programs for an integrated investigation of raw materials for applicability or the study of the composition and properties of the kaolins. To resolve successfully all questions associated with the problem of forming a mineral – raw materials base of kaolins it is necessary to develop and strengthen collaboration with geological-exploration and scientific-research organizations.

It should be noted that the production of kaolin in the Kyshtymskoe, Eleninskoe, and Plast-Rifei enrichment plants has been substantially decreased because of the lack of demand for enriched kaolin. This is also due to the increase price of kaolin on the internal market and the efforts of kaolin users to switch production to a cheaper raw material — raw kaolin. As a result of this situation, the enrichment plants do not have highly-qualified specialists.

One of the urgent near-term problems is the development of a commercial base of alkaline kaolins, which have been little studied in the Urals region. The study and additional exploration of alkaline kaolins in the Urals with development of methods for practical use of this material could serve as a base for organizing the production in this region of a substitute for feldspar for ceramics manufacturers.

The predicted resources of vein-quartz in Chelyabinsk oblast' are concentrated in Ufaleisko-Kyshtymskoe and Larinskoe quartz-bearing sites. According to the status on January 1, 2003, the government inventory in Chelyabinsk region includes 14 deposits of quartz raw materials. The reserves of granular quartz are concentrated in 10 deposits, of which five are being worked.

As a ceramic raw material, quartz sand and powdery quartz (marshalite) have not been explored in detail and have not been studied.

However, it should be noted that tests of powdery quartz under the production conditions of the former Yuzhnoural'skoe and Bogdanovich porcelain works have been performed. The results are satisfactory. Quartz sand from the Galyaminsk deposit is used in the production of ceramic granite.

The riches of the Urals can be used efficiently only if the government and manufacturers of ceramic products take an interest in doing so.

To increase the production of building ceramic it is necessary to search for new types of raw materials and develop new technologies and technological equipment which will make it possible to produce modern, high-quality articles with high productivity and low prices.

Another problem is to increase the efficiency of the production of ceramic brick, which was and remains the main building material used for walls.

Experts estimate that by 2010 construction using wall materials sold by the piece will predominate in the construction of low and high buildings and will comprise more than 50% of the total volume of housing built. However, in the market such materials with ceramic brick and blocks compete with silicate brick, cellular-concrete, keramzit-concrete, styrofoam blocks, and other materials, whose manufacturers are pursuing a successful technical and marketing plan. As result, ceramic brick is squeezed, in some regions very substantially, in the market.

According to Rosstat data, at the present time 460 brick plants with different capacity operate in the country. These plants are located in all regions of the Russian Federation. Some are very new, and imported new-generation integrated equipment has been installed in them. Some enterprises are rebuilding in stages, gradually increasing product quality, expanding the assortment of products, and increasing capacity. However, most medium-capacity plants cannot make substantial investments for technical reconstruction, so that they are forced to work with worn-out equipment. The result is low-quality brick, high energy-intensiveness, and low competitiveness in the market. This group includes 17 enterprises in the Chelyabinsk region which produce ceramic and facial brick. The enterprises have decent growth dynamics but the lack of resources and investments raises difficulties which they will not be able to overcome on their own in order to reach the planned level of production 740 million brick equivalents in the form of small-piece ceramic brick for different applications by the year 2010. Traditionally, natural raw materials combined with grog additives and fluxes are used to manufacture ceramic brick for different applications. For housing construction, it is necessary to use wall materials

with low density, low thermal conductivity, high strength, and high longevity. It is impossible to obtain such materials solely from low-melting clays, since these clays contain a substantial amount of impurities in the form of quartz sand, iron compounds, carbonates, micas, sulfates, and organic materials.

The increase in the demand for construction brick also makes it necessary to improve the technical-economic and decorative characteristics of the brick, which depend, as rule, on the type of materials used as well as on the structure of the phase composition of the fired ceramic.

However, because of the lack of high-quality clay, low-plasticity clays, loams, and various industrial wastes are used in production. To obtain high-quality brick from such raw materials it is necessary to make a comprehensive study of the brick, determine compositions, work out regimes for preparing and refining the raw materials as well as drying and firing regimes. In most cases, this is not available at many enterprises.

Today, the raw materials base of the industry is becoming an acute problem, which is gradually becoming more complicated because of the lack of reserve clay deposits for brick production which are located close to the operating plants. The cost of delivering raw materials is sometimes substantially higher than the cost of the raw material itself, and this is so even though since 1991 the reserves of such clays in Chelyabinsk oblast' increased by 9.3 million m^3 as a result of exploration of a number of deposits of low-melting clays.

The production of clays increased from 474 to 507 thousand m^3. Fifteen clay deposits are now being developed in the region. Clays from the Pervomaiskoe deposit, which are in the government inventory, are light-burning clays used in the production of facial brick. In addition, a number of enterprises use clay from the Nizhne-Uvel'skoe and southern section of the Berlinskoe deposits to manufacture facial brick.

To improve the physical and technical properties of the ceramic brick we are working together with personnel from the "Chelyabinsk zavod stroiindustrii Kemma" JSC and the Kopeisk and Korkino Brick Works to develop ways to use in the charge raw kaolin from the Poletaevskoe deposit and premixes obtained by enriching kaolin from the Zhuravlinyi Log deposit. The reserves from the Kopeiskoe and Uvel'skoe deposits of tripolitic clays as well as glauconite-bearing raw materials from the Karinskoe deposit can be used to manufacture construction brick.

The use of wastes from the power and metallurgical industries — granular blast-furnace slag and slags and ash from State Regional Electric Power Plants and Central Heat and Power Plants — in the production of building materials will greatly expand the raw materials base for manufacturing ceramic brick.

Integrated use of raw materials and technogenic products makes it possible to increase the production of many types of building products by 25 – 30%. The production costs will be 2 – 4 times lower than with raw materials obtained by the classical scheme.

In this connection, production engineers must play a larger role at enterprises. But the number of production engineers graduating from institutions of higher learning in the country has decreased substantially. Consequently, today, it is necessary to create at enterprises all possible conditions to maintain the remaining cadres of production engineers and to solve the problem of training engineering cadres.

The industry also does not have targeted professional preparation of workers. In addition, many scientific studies in the field of construction ceramics have been terminated in the last few years, and qualified specialists from special research organizations have left to work in other fields. Thus, the cadre problem has been added to the raw materials problem.

Among the tens of properties which undoubtedly give ceramics an advantage over other building materials, ceramic materials lose out only with respect to one criterion — their relatively high production energy-intensiveness. It is well known that the most energy- and labor-intensive operation in the production of ceramic brick is firing, which accounts for 80% of all expenditures on production and at least 90% of the environmental contamination. The direct losses of energy resources and their unproductive expenditures on the production of irretrievably lost material product reach 30%.

The staff at the Kazan' State Technical University established that in a number of brick works the heat energy consumption exceeds 4 MJ/kg fired product. In the countries of the European Union this indicator was 2.5 MJ/kg in 1991. It is known that the consumption of heat depends on the type of article, the initial raw material, and the type of firing furnace. German and Italian specialists have calculated that under ideal conditions 0.25 MJ/kg on average must be expended on firing brick; the rest of the heat comprises losses, the bulk of which is proportional to the firing time.

According to an analysis of the materials presented at exhibitions by leading enterprises the following firing times have been attained for various ceramic articles: 4.0 – 4.5 h for hollow brick and 3.5 – 5.0 h for facial brick.

A plant in Spain producing 120 million brick equivalents per year expends 0.5 MJ/kg on the production of articles with 40% empty space; the drying time is 2 h 40 min (in Anghou driers manufactured by the Serik group) and the firing time is 4 h 30 min (in tunnel furnaces from the same company). For such indicators, construction ceramic articles are becoming some of the least energy-intensive products. For comparison, at a Kazan' Construction Materials Works the drying time is 96 h, the firing time is 48 h, and the energy consumption is 3 MJ/kg. The firing time for brick at the Potanin Works ranges from 55 to 74 h and at the Kopeisk Works it is about 50 h.

The data presented above show that the production of ceramic wall materials is material- and energy-intensive. In addition, it should be noted that the current situation with the

furnace stock in the industry is unsatisfactory. Annular furnaces must be replaced with modern tunnel furnaces. At the same time most tunnel furnaces are notable for their high degree of physical wear. Only 5.6% of tunnel furnaces meet the technical-economic level of the requirements of world standards, and 35.3% do not meet the modern level and must be replaced by new furnaces. Chamber and tunnel driers also need to be rebuilt.

The fact that the quality of ceramic wall articles is inferior to the foreign level is explained by the facts that, first of all, the production parameters are suboptimal and, second, the clay refining equipment is not first class. The situation is best in the case of presses used to form ceramic brick. About 70% of the presses meet the modern level, and of these 15% meet world standards.

The ways which are emerging for efficient use of raw materials and fuel-energy resources can be divided into two groups.

The first group consists of general plant measures: maximum reduction of raw material and heat-carrier losses, complete recovery of heat from waste gases, and others.

The second group consists of improving technology, upgrading equipment, and developing progressive energy-conserving technologies, which make it possible to use the secondary fuel-energy resources and wastes from different industrial sectors as much as possible.

In solving the problem of improving the operation of a particular enterprise which produces ceramic brick, decisions must be made on the basis of the properties of the raw materials used and the technical and economic possibilities of the enterprise.

An examination of the status of construction ceramics at the federal and regional levels showed that there is a real need to create federal and regional scientific and technical coordination councils on the development of the ceramic industry and ceramic building materials within the Government of the Russian Federation and Region governments. In addition, federal and regional programs need to be developed for the following purposes:

development of the ceramic industry and ceramic construction materials;

development of a mineral – raw materials base for the ceramic, refractory, and glass industrial sectors.

To reach these objectives, obtain positive technical-economic results, and operate a ceramic industry in the Russian Federation at the modern level, it is necessary to develop organizational and economic levers of influence at the national level and governmental, political and civic organizations must show interest in the future of ceramics.